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PROCESSING FACTORS AND EMULSION CHARACTERISTICS

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Emulsion type sausages are a major product of the United States meat industry, amounting to over 2.5×10^9 pounds of product per year. This Laboratory has been concerned for a decade with the characteristics of meat emulsions and the scientific principles underlying their formation. A review of some of our principal findings for the benefit of this meeting seems especially fitting.

The emulsion sausage is actually a mixture of a true emulsion and particles of unemulsified muscle and fat. The more stable the true emulsion part of the mixture, the more stable will be the sausage as a whole. The emulsion is composed of fat globules enclosed in a matrix of denatured protein (Hansen, 1960). In forming this emulsion, the ability of the meat protein to form the necessary matrix is critical to successful sausage making. Therefore, in the very beginning of our work we devised (Swift *et al.*, 1961) a technique for measuring the emulsifying capacity of various meats, and other sausage ingredients, which has become a standard for this purpose in the United States.

Using the Swift technique for determining emulsifying capacity, we were able to elucidate several basic principles of emulsion formation. For example, we showed that the amount of fat emulsified was directly proportional to the rate at which fat was added to the mixture and that the higher the temperature attained during mixing, the less fat was emulsified. Both salt-soluble and water-soluble proteins were used in emulsification, and the efficiency of salt-soluble proteins as emulsifiers was much more concentration-sensitive than was that of the water-soluble proteins (Swift et al., 1961).

In further studies of the effect of proteins on emulsions, we showed in 1963 (Swift and Sulzbacher) that at three different salt levels, emulsifying capacity of the water-soluble proteins was much greater at a pH of about 5.2 than at either more alkaline or more acid conditions. For the salt-soluble proteins, however, emulsifying capacity increased rapidly from pH 5 to pH 6 and remained at a high level up to pH 8. Furthermore, the emulsifying capacity of the salt-soluble proteins improved slightly with increases in sodium chloride (ionic strength) content.

We next turned our attention to the fat component of the emulsion and, using differential thermal analysis, we were able to analyze the melting characteristics of the pork and beef fats generally found in sausage materials (Townsend et al., 1963). Both beef and pork fats were found to melt in two ranges, from 3° to 14°C and from 18° to 30°C for beef fats; and from 8° to 14°C and 18° to 30°C for pork fats. Stable emulsions were easily prepared with all these fats at levels of 12% added fat. At fat levels of 22%, stability was related to the melting point of the fat. The high melting fats yielded stable emulsions while those melting at low temperature did not. Chopping temperature also affected the stability of the emulsions, high temperatures tending more to instability (Swift et al., 1968).

Our most recent interest in this area has been an investigation of the effects of chopping speeds on the processing characteristics of frankfurters (Townsend et al., 1970). Emulsions were chopped in a specially modified silent cutter so that knife speeds of 1500, 2500, and 5000 rpm were attained. Final chopping temperatures from 7.2°C to 29.4°C were investigated. The rate of temperature rise was found to be dependent on chopping speed, as might be expected. Thirty minutes chopping at 1500 rpm was required to obtain the same temperature rise as three minutes at 5000 rpm. When chopped to 7.2°C, emulsions prepared with beef or pork fat had higher viscosities than those prepared with cottonseed oil. From 12.8°C to 29.4°C there was very little difference in viscosity, although the beef and cottonseed oil tended to be higher than pork fat. Also the viscosity values did not seem to be related to emulsion stability. Shrinkage in the smokehouse, an important practical parameter, was not related to chopping speed but was related inversely to the total fat content and to the type of fat. Fat caps were noted only in frankfurters which received insufficient chopping. Greater stability was obtained by chopping at faster speeds to higher temperatures than was obtained at slow speed and low temperature. The optimum temperature for emulsion formation increased with increasing knife speed.

An important practical consideration is the ease with which the finished frankfurter can be peeled. In this work (Townsend et al., 1970), poor peeling, when it was observed, was associated with chopping to high temperature. Skin strength, another practical parameter, was observed to be greatest in frankfurters prepared by chopping at slow speeds or too low temperatures, or both. This we think results from greater migration of protein to the denaturing surfaced during cooking in those sausages with the weakest emulsions.

The work reviewed has been noteworthy in both its practical applications and the fundamental nature of the insight it has given of the process of emulsification in meat products.

REFERENCES

Hansen, L.J. 1960. Emulsion formation in finely comminuted sausage. Food Technol. 14, 565.

Swift, C.E., C.Lockett, and A.J.Fryar. 1961. Comminuted meat emulsions - The capacity of meats for emulsifying fat. Food Technol. 15, 468.

Swift, C.E., and W.L.Sulzbacher. 1963. Comminuted meat emulsions: Factors affecting meat proteins as emulsion stabilizers. Food Technol. 17, 106.

Swift, C.E. 1965. The emulsifying properties of meat proteins. Proc. Meat Industry Research Conference, Chicago, March 1965, p.78.

Swift, C.E., W.E.Townsend, and L.P.Witnauer. 1968. Comminuted meat emulsions: Relation of the melting characteristics of fat to emulsion stability. Food Technol. 22, 117.

Townsend, W.E., L.P.Witnauer, J.A.Riloff, and C.E.Swift. 1968. Comminuted meat emulsions: Differential thermal analysis of fat transitions. Food Technol. 22, 71.

Townsend, W.E., S.A.Ackerman, L.P.Witnauer, W.E.Palm, and C.E. Swift. 1970. Pres. Institute of Food Technologists, San Francisco, May 24-28, 1970.